

Remarks

The specification and claims have been amended to address the various objections and rejections made by the Examiner. Specific points raised by the Examiner are discussed below.

Drawings

The Examiner has objected to the drawings on the ground that element S320 in Fig. 7 reads “without modifying loop”, whereas it should read “while modifying loop” (paper no. 6, page 5, ¶ 4). Submitted herewith are a new set of drawings in which this has been corrected.

Claims

1. Rejection under 35 U.S.C. § 112, First Paragraph

Claims 1-4 stand rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the enablement requirement (pages 5-6, ¶ 6). Specifically, the Examiner alleges that the selection of transfer points and the motivation for moving or copying them or points that post-dominate them is not clearly described. Applicants respectfully traverse this ground for rejection.

A little background may be in order here. The invention especially deals with the case where a transfer point (as discussed below) is located within a loop. It is important to deal with such a case because transfers from an interpreter or non-optimized code often occur to loops that iterate many times. To compile a method including transfer points, each transfer point is represented by a special edge linked from the entry node to the transfer point on the control flow graph of the method. When a transfer point is located in a loop other than at the top of the loop, the loop becomes irreducible because of the existence of the special edge, even if the original loop was reducible. Because most conventional loop optimizations deal only with a reducible loop, such irreducible loops cannot be optimized using such conventional loop optimizations. Consequently, the performance of such a loop decreases compared to the case where no transfer point exists in the loop.

An object of the invention is thus to eliminate transfer points from a loop containing them to make the loop reducible by moving them to the top or copying a part of a region of the loop. Figures A and B below illustrate this further.

Fig. A shows an example of moving a transfer point from the middle of a loop to the top of the loop. More particularly, Fig. A shows on the left a loop (nodes 1-3) having an entry point (node 1) at its top as well as a transfer point (node 2) along its length to which control may pass other than through the entry point (i.e., from another routine). Because of the transfer point at node 2, the loop is irreducible and many common optimization techniques cannot be used. In accordance with one aspect of the invention, the transfer point is moved (if this can be done without a problem occurring) from node 2 to node 1 at the top of the loop, as shown on the right in the figure, so that the loop is now reducible.

Similarly, Fig. B shows an example of copying a region from the top of a loop to a point that post-dominates the top of the loop and the transfer points. At the very left of the figure is shown a loop (nodes 1-7) having an entry point (node 1) and a transfer point (node 2) to which control may pass other than through the entry point. Node 4 of the loop is said to post-dominate nodes 1 and 2 since every path of execution passing through node 1 or 2 subsequently passes through node 4. Again, because of the transfer point at node 2, the loop is irreducible and many common optimization techniques cannot be used.

In accordance with another aspect of the invention, therefore, the region (nodes 1-3) from the top of the loop (node 1) to a point (node 4) that post-dominates the top of the loop and the transfer point (node 2) is copied to a location immediately preceding the loop. More particularly, nodes 1-3 have been copied as nodes 1'-3' (as the nodes shown as black circles will be identified here), with node 1' having directed edges to nodes 2' and 3' and with nodes 2' and 3' having directed edges to post-dominating node 4. With this change, the loop containing nodes 1-7 has but a single entry point (now node 4), allowing conventional optimization techniques to be used.

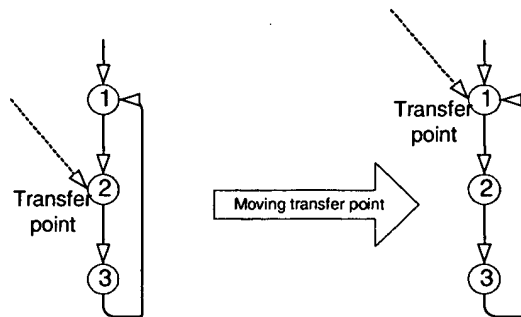


Fig. A: An example of moving transfer point

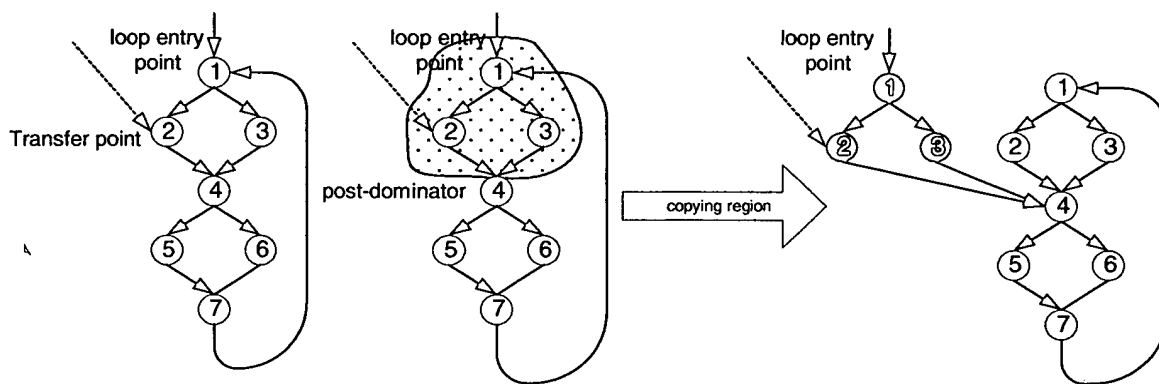


Fig. B: An example of copying a region from entry point to the post-dominating point

Except for applicants' inventive steps of moving transfer points and copying regions of a loop, all of this—including the notions of transfer points, dominating nodes and irreducible loops—is well known in the art, as shown, for example by the discussion in Section 10.4 (pages 602-608) of Aho et al., Compilers: Principles, Techniques, and Tools (1986), cited by the Examiner.

Accordingly, even without an extended discussion of these topics in the specification, the identification of transfer points, the motivation for eliminating such transfer points from a loop, and the effect of moving such points or copying code portions would be readily apparent to those of ordinary skill in the art who have read applicants' specification. Such skilled artisans would similarly know how to determine whether transfer points could be safely moved, as well as how to accomplish the moving and transferring steps. Therefore, applicants' specification, which is directed to persons skilled in the art, fully complies with the first paragraph of 35 U.S.C. § 112.

2. Rejection under 35 U.S.C. § 112, Second Paragraph

Claims 1-4 also stand rejected under 35 U.S.C. § 112, second paragraph (paper no. 6, page 6, ¶ 8). The Examiner asserts that there is insufficient antecedent basis for “the privatization” in line 12 of claim 1, as well as in line 13 of claim 4 (page 6, ¶ 9). Applicants have amended claims 1 and 4 so that these lines refer merely to “privatization”, which does not require an antecedent.

3. Rejection under 35 U.S.C. § 101

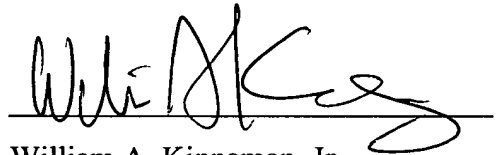
The Examiner asserts that claim 4 is non-statutory since it is allegedly directed to a program per se, as distinguished from a sequence of instructions on a computer-readable medium (pages 6-7, ¶ 11). Claim 4 has been amended so that it is now directed to “a program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform method steps” as defined in the claim. As amended, claim 4 is directed to a computer-readable medium, an article of manufacture that clearly constitutes patentable subject matter under 35 U.S.C. § 101.

Conclusion

Entry of this amendment and reconsideration of the application as amended are respectfully requested. It is hoped that upon such consideration, the Examiner will hold all claims allowable and pass the case to issue at an early date. Such action is earnestly solicited.

Respectfully submitted,
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By

A handwritten signature in black ink, appearing to read 'William A. Kinnaman, Jr.', written over a horizontal line.

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